

JAPAN

EDICT OF GOVERNMENT

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JIS Z 9111 (1988) (English): Lighting of roads

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*The citizens of a nation must
honor the laws of the land.*

Fukuzawa Yukichi

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JAPANESE INDUSTRIAL STANDARD

Lighting for Roads

JIS Z 9111—1988

Translated and Published

by

Japanese Standards Association

In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

1. Scope

This Japanese Industrial Standard specifies the qualitative base of lighting for roads exclusive of tunnels.

2. Definitions

For the purpose of this Standard, the following definitions apply. Other terms and definitions are in accordance with JIS Z 8113.

2.1 Terms Relative to Roads

- (1) roads Establishments offered to general transit.
- (2) users of road Walkers and drivers of vehicles, who use roads.
- (3) general parts The road parts free from sudden change in width and route, or free from intersection and join . branch in traffic.
- (4) roadway width Width of the part of road used exclusively for the passing of vehicles.
- (5) visual environment Environment visible in a field of view of users of road.

2.2 Terms Relative to Lighting

- (1) road surface luminance Luminance within the width of roadway in the range of 60 m to 160 m ahead from the position of eye of a driver.
- (2) overall uniformity ratio of luminance Ratio of luminance giving the degree of uniformity in distribution of road surface luminance which exerts an influence upon how clearly a driver can see the subjects on the road surface.

Applicable Standards:

JIS C 8131-Roadway Lighting Fittings for Traffic Route

JIS Z 8113-Glossary of Lighting Terms

JIS Z 9110-Recommended Levels of Illumination

JIS Z 9116-Recommendation for Lighting of Traffic Tunnels

- (3) uniformity ratio of luminance of lane axle Ratio of luminance giving the degree of uniformity of distribution of the apparent brightness in front of road surface.
- (4) glare control mark Mark giving the degree of control on unpleasant glare due to the road lighting numerically. As its value is larger, so is smaller the glare.
- (5) pole lighting method Method to illuminate by equipping a pole with luminaires and arranging the poles along the road.
- (6) high mast lighting method Method to illuminate a large area from a few of lighting units by equipping a high mast with luminaires.
- (7) lighting method with equipping at structure Method to illuminate by equipping the structure, which has been constructed on or near the road, with luminaires directly.
- (8) catenary lighting method Method to illuminate by stretching a catenary line on the road and hanging luminaires.
- (9) array of luminaires Arraying method for the luminaires along roads. One side array, zigzag array, face to face array with the other and the like are included in this.
- (10) arrangement of luminaires Arrangement method of luminaires to be decided by the equipping height of luminaires, overhang, angle of inclination and intervals of luminaires.
- (11) interval of luminaires Horizontal distance between neighboring two luminaires, which has been measured along the center line of the road.
- (12) one side array Method arraying luminaires at one side of the road.
- (13) zigzag array Method arraying luminaires alternately at both sides of the road.
- (14) face to face array Method arraying luminaires so that they are face to face at both sides of the road.

3. Purpose of Lighting for Roads

The lighting for roads shall have the purpose to secure a safe and smooth pleasant road traffic by improving the visual environment of users of road at night chiefly.

4. Requirements of Lighting for Roads

In designing the lighting for roads, cares shall be taken of the following lighting requirements according to the kind of users of the road intended for the object of lighting.

4.1 Requirements for Motorcar Drivers The roads having drivers of motorcar and moped as the main constituents shall meet the following requirements.

- (1) When seeing from the direction of a driver, the road surface luminance shall be high sufficiently and be uniform as far as possible.
- (2) The glare of luminaire shall be subject to sufficient restriction so that it will not give the driver unpleasant feeling.
- (3) The luminaires shall be arranged and positioned so that the information of change in route of the front road, presence of special places like the intersection, crossing point, joining point, etc. and the structure of that lane, and the like can be transmitted to the driver without mistake.
- (4) The lighting facilities shall not impair the road and its surrounding view.

4.2 Requirements for Walkers The road being chiefly used by walkers and bicycles, hereinafter referred to as walkers, shall meet following requirements:

- (1) The illuminance of the road surface seen by walkers shall be high sufficiently and be uniform as far as possible.
- (2) The road shall be high sufficiently in vertical illuminance and walkers can distinguish one another.
- (3) The glare of illuminaires shall be sufficiently restricted not to give walkers unpleasant feeling.
- (4) The light-source colour shall be adequate to the environment and be excellent in colour rendering properties.
- (5) The lighting facilities shall not impair roads and the surrounding scene.

5. Base of Lighting for Road

The lighting for road equipped at roads should meet preferably all of the bases specified in each item mentioned below according to kind of users of the road intended for the subject, class of road, traffic, general traveling speed of motorcar, the building condition of other lighting near the road and the like.

5.1 Base of Lighting for Road to Drivers The base of lighting to drivers of each of straight line parts and curved line parts and special places shall be in accordance with the following.

5.1.1 Straight Line Part of General Part The base for lighting to the road of straight part of general part shall be as follows:

- (1) Average Road Surface Luminance (L_r) The value of average road surface luminance (L_r) for the dried road surface visible from the position of driver shall be maintained at not less than the values given in Attached Table 1 according to the class of the road. The measurement of average road surface luminance shall be in accordance with Appendix.
- (2) Overall Uniformity Ratio and (U_o) and Lane Axle Uniformity Ratio (U_l)
The overall uniformity ratio (U_o) and lane axle uniformity ratio (U_l) of the dried road surface when seeing from a driver side shall be not smaller than the values given in Attached Table 1 according to class of roads. Provided that U_o shall be ratio (L_{min}/L_r) of the minimum luminance (L_{min}) on the road surface and average road surface luminance (L_r) and U_l shall be ratio (L_2/L_1) of the minimum luminance (L_2) on the center line of the lane and the maximum luminance (L_1) on the center line of the lane. The measurement of these largest luminance and the smallest luminance (these shall be referred to as partial luminance) shall be in accordance with Appendix.
- (3) Glare Control Mark (G) It should be desirable that the glare control mark (G) of the lighting facilities to be calculated according to the following formula becomes not smaller than the values given in Attached Table 1.

$$G = SLI + 0.97 \log L_r + 4.41 \log h' - 1.46 \log p$$

where SLI : intrinsic glare index of luminaire

L_r : average road surface luminance (cd/m^2)

h' : height from the position of eyes of an observer to luminaire, that is: (equipment height of luminaire) -1.5 (m)

p : number of luminaires per one kilometer of road territory

- (4) Lighting Method The lighting method shall be of pole lighting type, as a rule. Provided that high mast lighting type, type of equipping structure, catenary lighting type, etc. may be used individually or jointly.
- (5) Light Source The light source to be used shall be selected adequately with considering the following items according to class, purpose, locational conditions, etc.
 - (a) Overall efficiency including lamp and stabilizer
 - (b) Life and luminous-flux maintenance factor
 - (c) Colour of light source and colour rendering properties

- (6) Luminaires The luminaires to be used shall be those specified in JIS C 8131 as a rule and the luminaires meeting the restrictive conditions of the glare given in Attached Table 1 according to class of road shall be selected and used.
- (7) Placing and Array of Luminaires The placing and array of luminaires shall be as follows according to width of road and its sectional structure (see Attached Fig. 1).
- (a) Height of Luminaires Equipped (H) The height of luminaires equipped (H) shall be not less than 10 m as a rule. Provided that where restrictions are required for keeping lighting effects such as locational relation to road structure and other structures, and prevention of other roads from the glare and where the neighborhood of air port and the like have been restricted by laws and ordinance, this rule is excepted. The height (H) of luminaires equipped of the consecutive road equal in width of lane shall be invariable as a rule.
- (b) Array of Luminaires The array of luminaire shall be as follows: Select and use an adequate arrangement from among one side arrangement, zigzag arrangement and facing each other arrangement according to sectional structure of road, width of roadway part (W) and luminous intensity distribution of luminaires. These may be combined according to sectional structure of road and width of roadway part (W).
- (c) Overhang (Oh) of Luminaire It is advisable that the overhang (Oh) of luminaire is kept short as far as possible. Provided that where the trees stand so close together along the road that they shade the light of the lighting for road, this rule is excepted.
The overhang (Oh) at the lighting facilities for a cosecutive road shall be constant as a rule.
- (d) Angle of Inclination of Luminaires (θ) The angle of inclination (θ) of luminaires shall be zero and over to five degrees incl. as a rule.
- (e) Interval of Luminaires (S) The interval of luminaires (S) shall meet the base of overall uniformity ratio (U_o) and lane axle uniformity ratio (U_l), which are given in 5.1.1. (2), according to the height equipped (H) and array of luminaires.

5.1.2 Curved Part of General Part The base of lighting for roads of the curved part ⁽¹⁾ of general part shall be as follows:

Note ⁽¹⁾ The curved part is referred to as the part of road of 1000 m and under in radius of curvature.

- (1) General Base of Lighting The base of lighting except array of luminaires and interval of luminaires (S) shall be in accordance with 5.1.1 as appropriate.

- (2) Array and Interval (S) of Luminaires The array of luminaires at the curved part shall be reduced as compared with the intervals of the straight line part according to the array of luminaires of the straight line part connecting with this, hereinafter referred to as straight line part, and the interval (S) of luminaires shall be reduced as compared with the interval of straight line part according to its radius of curvature.

At curved parts with very small radius of curvature or at sudden flexures, cares shall be taken not to misjudge the existence of sudden curved part or flexure and the changing condition of route of road due to the array of luminaires at the same time of reducing the interval of luminaires (S).

5.1.3 Special Places The base of lighting for special places shall be in accordance with 5.1.1, as appropriate. Provided that the special places as mentioned in the following (1) to (9) shall comply with the following requirements:

- (1) Crossing, Confluence · Separation Points The arrangement and array of the luminaires in the neighbourhood of crossing, confluence and separation points of road shall be such that motor drivers (approaching to the crossing at the same time with illuminating the front in the running direction of motorcars being in course of changing the direction in addition to general effects of the lighting for road) can confirm visually the existence of a crossing and the presence and running condition of other motorcars approaching to the crossing from a place sufficiently ahead. Example of basic arrangement of luminaires at simple crossing point is shown in Attached Fig. 2.

In arranging and arraying luminaires at crossing or confluence · separation points complicated in route structure, it is advisable to investigate the arrangement of luminaires by perspective drawings from each point of the road approaching to these so that motor drivers approaching to these will not misunderstand route, advancing direction, traffic signals and others.

- (2) Cross Footwalk In arranging and arraying the luminaires in the neighbourhood of cross footwalk, cares shall be taken so that motor drivers can confirm visually the state of walkers during crossing and walkers starting to cross the road. Attached Fig. 3 gives an example of standard arrangement of luminaires at a cross-footwalk.
- (3) Bridge The luminaires to be equipped at the road connecting with this bridge shall be used correspondingly. Provided that the luminaires easy to harmonize with the structure and design of bridge can be used, as required. Provided that the luminous intensity distribution shall be in accordance with JIS C 8131, as appropriate.
- (4) Rail Road Crossing The standard arrangement of luminaires in the railroad crossing and its neighbourhood where the lighting has been equipped at the road before and behind the crossing shall be in accordance with 5.1.3 (2), as appropriate. Provided that cares shall be taken so that the luminaires to be used will give the train men of rail road rolling stock the least glare.

- (5) Grade Separation Part The base of lighting for grade separation part and its neighbouring road shall be in accordance with 5.1.1 and 5.1.2, as appropriate. Provided that cares shall be taken so that the lighting for plural cross roads will not give motor drivers passing the grade separation part unpleasant glare or will not guide the wrong route. Where tunnels or structures equivalent thereto exist at the grade separation part, JIS Z 9116 shall be applied correspondingly.
- (6) Place Changing Suddenly in Width The arrangement and array of luminaires in the neighbourhood of a place changing suddenly in road width, especially a place decreasing in width of road shall be such that the motor driver can confirm visually and sufficiently the state of a place changing suddenly in width in addition to general effects of the lighting for road from a remote distance.
- (7) Place Changing Suddenly in Route The arrangement and array of luminaires in the neighbourhood of a place changing suddenly in plane route shall be in accordance with 5.1.2 as appropriate. The array of luminaires in the neighbourhood of a place changing suddenly in vertical route shall be such that the motor driver can confirm visually and sufficiently the state of sudden change in route in addition to general effects of the lighting for road from a remote distance.
- (8) Bus Stop The arrangement and array of luminaires in the neighbourhood of bus stops shall be such that the motor driver can confirm visually and sufficiently the existence of bus stop and the state in its neighbourhood from a remote distance in addition to general effect of road lighting.
- (9) Parking Place and Resting Facilities The parking place and resting facilities shall be such that the safety of motorcars and walkers in the parking places and resting facilities can be secured and furthermore, the illuminance to be maintained shall be in accordance with the item of parking place of JIS Z 9110, as appropriate.

5.2 Lighting Criterion of Roads for Walkers It is to be desired that the lighting of road for walkers meets all of the following criteria:

- (1) Illuminance The illuminance to be maintained for the roads used by walkers shall be not smaller than the values given in Attached Table 2 according to walker's traffic (at night) region and place. Provided that the illuminance of cycle park shall be that of the road much in traffic correspondingly.
- (2) Lighting Method The lighting method shall be of pole lighting method as a rule. Provided that the method of equipping the structure with luminaires may be used or be used jointly with other method according to the structure of road, its traffic conditions and others.
- (3) Light Source An appropriate light source shall be selected in accordance with 5.1.1 (5), as appropriate.

(4) Luminaires The luminaires shall be in accordance with JIS C 8131, as appropriate.

(5) Arrangement and Array of Luminaires

- (a) The equipment height of luminaires shall be not less than 4 m and not less than 1.0 time of the width of the road part to be used by walkers as a rule.
- (b) The array of luminaires shall be one side as a rule.
- (c) The interval of luminaires shall be not more than five times of the equipment height as a rule.

6. Maintenance and Supervision for Lighting Facilities

It is advisable for lighting facilities to be maintained and supervised with taking care of the following items:

- (1) Inspection of the lighting condition of light source
- (2) Individual and collective exchange of light source
- (3) Inspection of equipment condition of luminaires
- (4) Inspection and repair of pole for lighting use
- (5) Inspection and repair of wiring and switches
- (6) Cleaning of luminaires

Attached Table 1. Base of Lighting for Road toward Motor Drivers

Class of roads	Traffic class and traffic density of motorcar	Average road surface luminance L_r ⁽²⁾ (cd/m ²)	Overall uniformity ratio U_o	Lane axle uniformity ratio of illuminance U_i	Glare control mark G ⁽³⁾
Road in which the upper lane and the lower lane are separated and all of crossings are grade separation and the traffic of motorcar is limited completely	High speed motorcar traffic large in traffic density of motorcar at night chiefly	2	0.4	0.7	6
Important road for exclusive use for motorcar traffic attended with an independent lane for low speed traffic and a road for walkers in many cases.		2	0.4	0.7	5
Ordinary road of important city part and local part	Moderate speed motorcar traffic being much in motorcar traffic at night chiefly or moderate speed mixed traffic being much in motorcar traffic	2	0.4	0.5	5
Road in city area or shopping center, or road leading to the area of government office. The motorcar traffic in this area are mixed with low speed traffic, walker traffic and the like which are heavy in traffic.	Mixed traffic of which the traffic at night is fairly much and its large part is low speed traffic or walkers.	2	0.4	0.5	4
Road connecting the residential district (residential road) with the above-mentioned roads	Mixed traffic ⁽⁴⁾ comparatively low in regulation speed and moderate in traffic at night chiefly.	1	0.4	0.5	4

Notes ⁽²⁾ Where the lighting environment around the road is dark, the value of L_r may be taken as 1/2.

⁽³⁾ Where the lighting environment around the road is dark, it is advisable to increase value of G by one.

⁽⁴⁾ Where the traffic is little, the value of L_r may be taken as 1/2. Provided that value of L_r shall not be taken as under 0.5 cd/m² regardless of the specifications of Note ⁽²⁾.

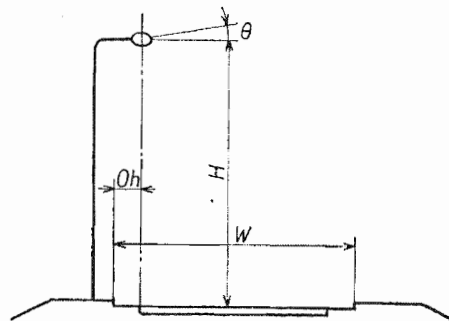
Attached Table 2. Base of Lighting for Road toward Walkers

Walkers' traffic at night	Area	Illuminance (lx)	
		Horizontal illuminance (⁵)	Vertical illuminance (⁶)
Road much in traffic	Residential district	5	1
	Commercial district	20	4
Road little in traffic	Residential district	3	0.5
	Commercial district	10	2

Notes (⁵) The horizontal illuminance is average illuminance on the road surface of footwalk.

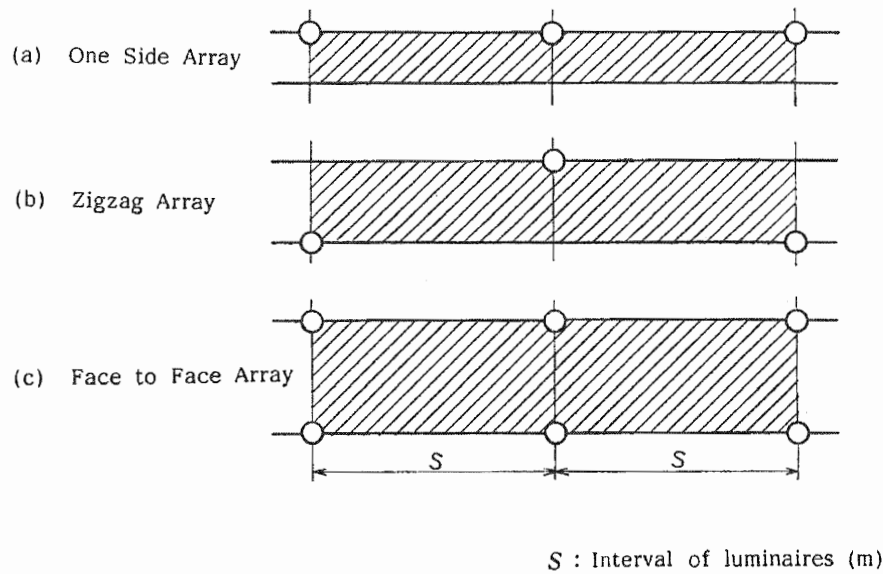
(⁶) The vertical illuminance is the minimum illuminance on the vertical plane rectangular to the axis of road of 1.5 m in height from the road surface on the center line of the footwalk.

Attached Fig. 1-1. Equipment Height of Luminaires, Overhang and Angle of Inclination

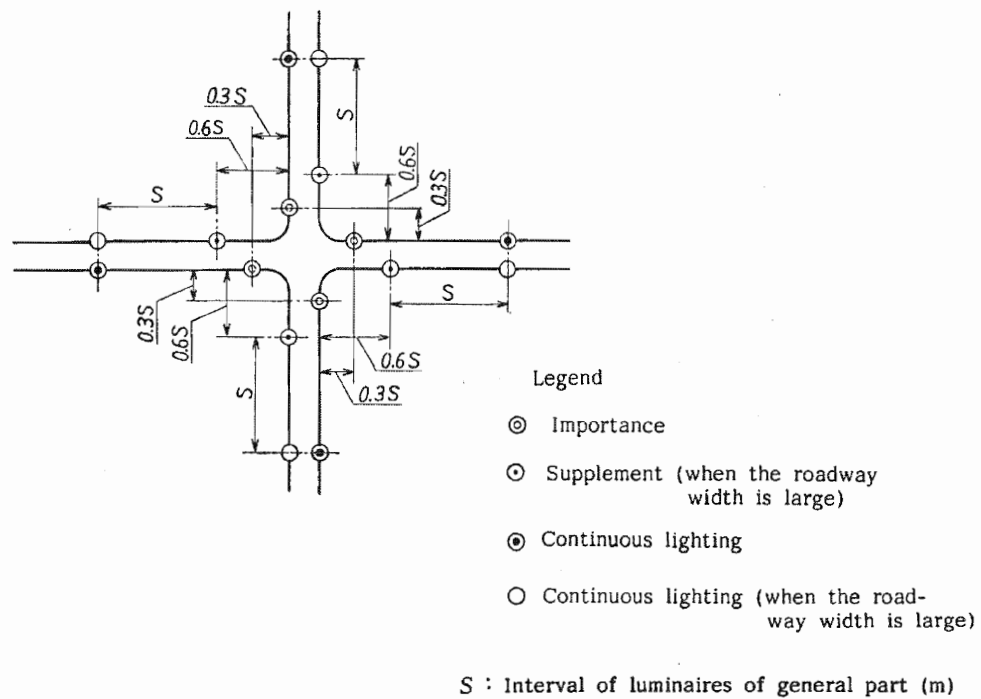


W : Roadway part width (m)
 H : Equipment height of luminaires (m)
 Oh : Overhang (m)
 θ : Angle of inclination (degree)

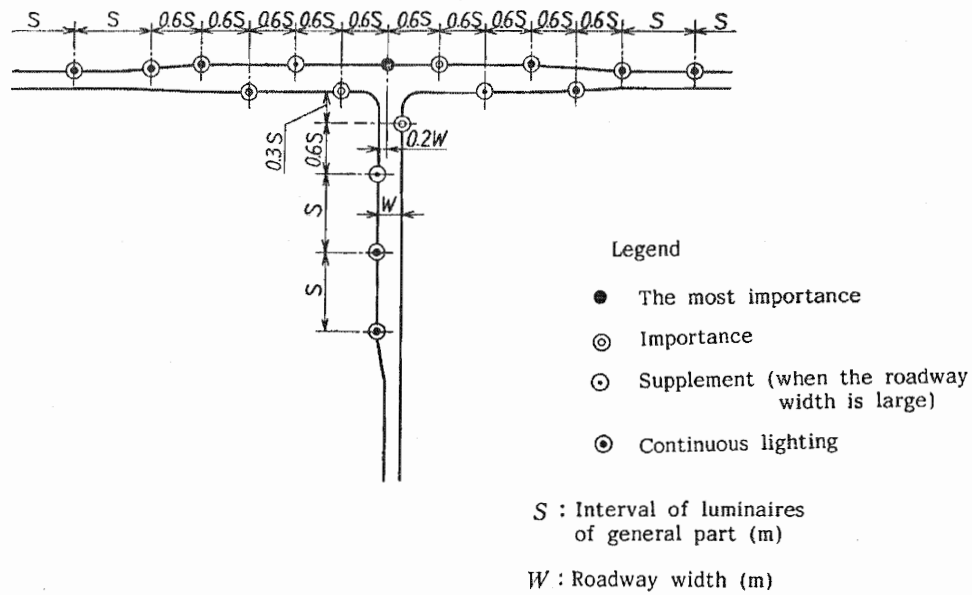
Attached Fig. 1-2. Array of Luminaires



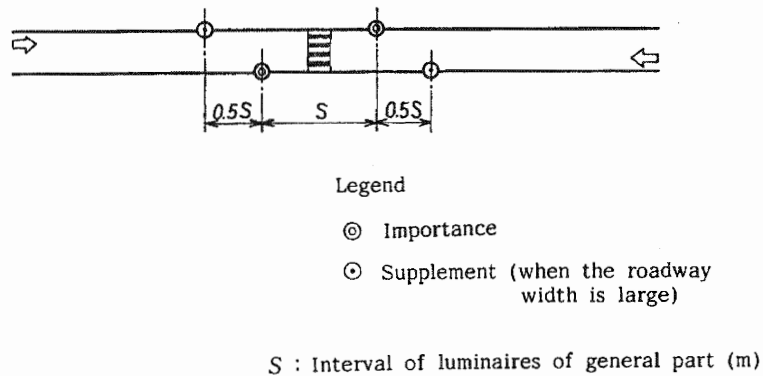
Attached Fig. 2-1. Example of Arrangement of Luminaires at Cross Roads of the Road Having Width of the Same Degree



Attached Fig. 2-2. Example of Arrangement of Luminaires at T-Junction



Attached Fig. 3. Example of Arrangement of Luminaires Around the Pedestrians' Crossing (Where the General Part Is Free from Lighting Facilities)



Appendix Measuring Method for Road Surface Luminance

1. Scope

This Appendix specifies the measuring method for average luminance of road (average road surface luminance) and partial luminance.

2. Measuring Method for Average Luminance

2.1 Measuring Range and Measuring Object The measuring range shall be the dried road surface of the roadway 60 m to 160 m in front of a luminance meter unless especially specified. The road part free from vehicular traffic such as separate band shall not be included in the measuring object, and in the road equipped with separate band and the like, the measurement shall be carried out independently for each road separated by separate band and the like.

2.2 Luminance Meter The luminance meter to be used for measurement shall be an average luminance meter having a trapezoidal field vision for measurement, which corresponds to the perspective view of the road surface of the measuring object as given in Appendix Fig. 1. Provided that an ordinary luminance meter having a circular field view for measurement of 2 min and over to 6 min incl. in diameter may be used.

2.3 Fundamental Position of Luminance Meter

- (1) When using the average luminance meter, the fundamental position of the head of the average luminance meter to be used for measurement shall be the point of 1.5 m in height on the road surface and 1/4 from the left of the width of road surface to be measured as a rule (see Appendix Fig. 1).
- (2) When using an ordinary luminance meter, the fundamental position of the head of the luminance meter shall be the position of 1.5 m in height on the road surface and 90 m in distance parallel to the axis of road from the point of intersection (point of measurement) of the lattice on the road surface specified in 2.4 Measuring Method.

2.4 Measuring Method

- (1) The measurement of average road surface luminance by using the ordinary luminance meter shall be as follows: Select any one of the rows of luminaires being arrayed along the road freely after letting the road surface part constituting the measuring object coincide with the visual field for measurement of luminance meter accurately. Divide the section (named 'standard section') of road surface between two luminaires, which are arrayed continuously as shown in Appendix Fig. 2, into four sections and measure the average luminance corresponding to each of the measuring territories of A, B, C and D of Appendix Fig. 2. In this case, the distance between the base of visual field of measurement of the trapezoid and the head of luminance meter shall be 60 m as shown in Appendix Fig. 1. The arithmetic average of these four times' average luminances shall be taken as an average road surface luminance.

- (2) The measurement of average road surface luminance by the use of an ordinary luminance meter shall be as follows: Select one of optional standard section including the road surface constituting the measuring object of the average road surface luminance in accordance with (1) as appropriate regardless of the specifications of 2.1 and take the average value of road surface luminances of this section as average road surface luminance.

In measuring average road surface luminance, divide this standard territory of road surface into lattice at equal intervals in the direction of length and width respectively and take the point of intersection as a point of measurement and measure the road surface luminance. In measurement of road surface luminance, take the position of luminance meter at 90 m constantly from a point of measurement, move that luminance meter before-behind and right-left on the road surface according to the place of point of measurement and measure the luminance of a point of measurement on each lattice to take the arithmetical average of those values as the average road surface luminance.

3. Measuring Method of Partial Luminance

3.1 Range of Partial Luminance and Measuring Object The range of partial luminance and measuring object shall be a dried road surface of three meters in the length direction of road and 0.3 m in width direction in dimensions on the road surface unless especially specified.

3.2 Luminance Meter The luminance meter to be used for average road surface luminance shall be used, as appropriate. When using average luminance meter, the average luminance meter having the visual field of measurement corresponding to the trapezoid as shown in Appendix Fig. 3 or the large sized trapezoid nearly similar to this shall be used as a rule.

When using an ordinary luminance meter, it shall have visual field of 6 min in visual diameter as a rule.

3.3 Fundamental Position of Luminance Meter The fundamental position of luminance meter shall be a position of 1.5 m above the road surface where is 90 m apart from point of measurement on the line parallel to the axis of road passing the point of measurement as a rule. Provided that the position of head of luminance meter may be lowered according to the size of visual field of measurement where the average luminance meter is used and in proportion to this, the distance to the point of measurement may be reduced. (The measuring angle to the road surface shall be about one degree).

When using an ordinary luminance meter, the position of the head of luminance meter shall be 0.15 m above the road surface for the circular visual field of 6 min in diameter of visual angle and be measured from 7.5 m in distance from the point of measurement.

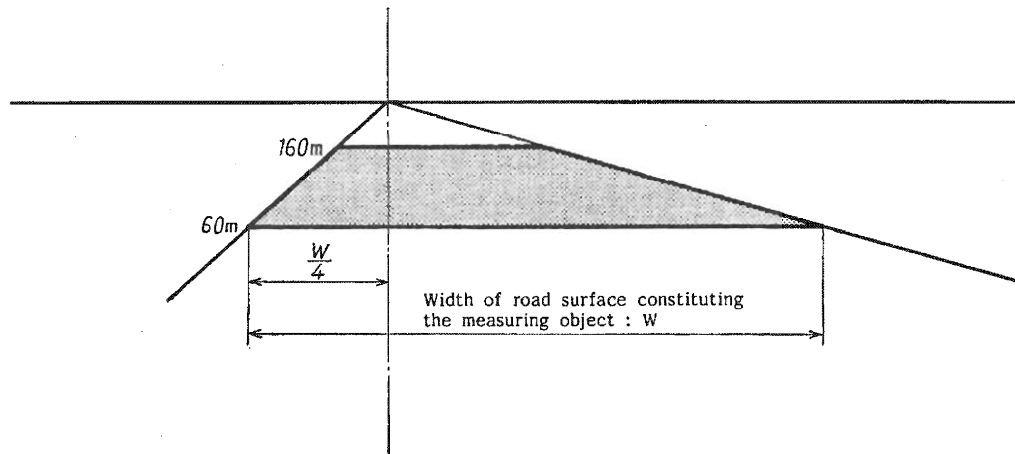
3.4 Measuring Method When measuring the luminance distribution on the road surface, the method to measure the average road surface luminance by using the ordinary luminance meter of 2.4 (2) regardless of class of the luminance meter to be used shall be applied, as appropriate. Provided that when using the average luminance meter is used, the visual field of measurement shall be recoincided with the part of the road surface constituting the measuring object accurately.

When measuring the maximum or the minimum luminance, observe the whole road surface constituting the object of average luminance visually and measure the luminance of the road having an area equal to this range at several points near the place to be seen most brightly or most darkly.

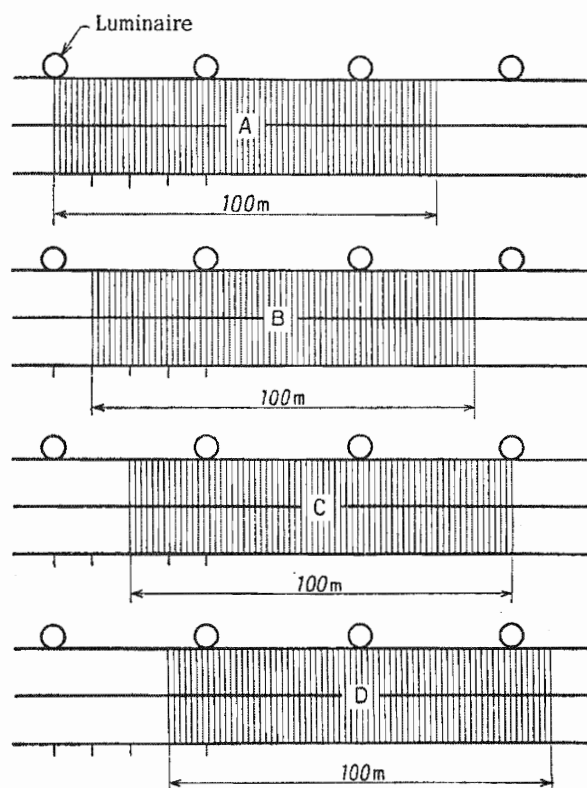
4. Cautions during Measurement

- (1) Cares shall be taken not to cause error in the results of measurement due to dust, fog, smoke, etc. in the air.
- (2) The luminance meter to be used shall meet the characteristics required for ordinary luminance meter, which are spectral sensitivity, linearity, polarized light characteristics, temperature characteristic, humidity characteristic, etc.

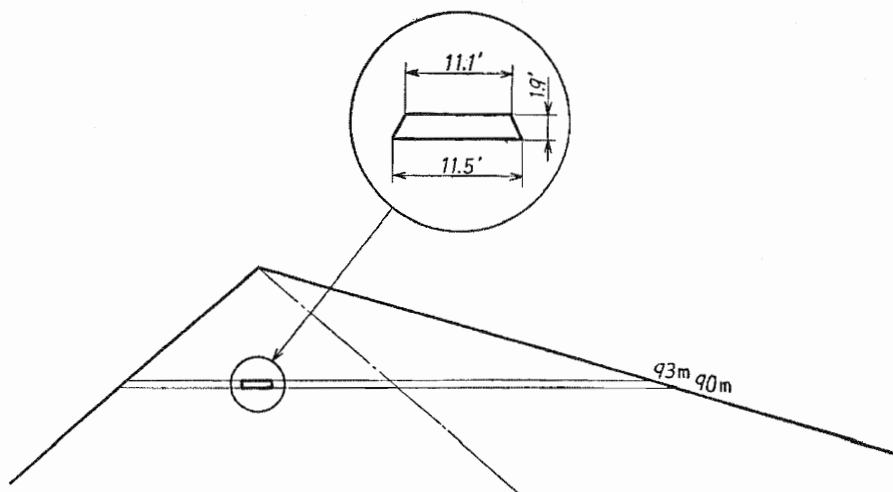
Appendix Fig. 1. Example of Visual Field of Measurement for Average Road Surface Luminance



Appendix Fig. 2. Measuring Method of Average Road Surface Luminance



Appendix Fig. 3. Example of Visual Field of Measurement of Partial Luminance



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